

Appendix B

Signal-to-Noise Ratio Reference

Signal-to-noise ratio formulas provide personnel involved in EA the tools that are necessary to compute jamming power outputs and distances. These products are necessary to fully plan and/or execute EA operations

RATIO FORMULA

B-1. The ratio formula is used to compute the maximum distance a jammer can be from a target and still be effective (Figure B-1).

$$d_j = d_t \sqrt[n]{\frac{P_j}{P_t K \left(\frac{h_t}{h_j} \right)^2}}$$

- f** Frequency (50 MHz)
- dt** Enemy transmitter location to target receiver location distance in km (9 km)
- Pt** Power output of enemy transmitter in watts (5 watts)
- hj** Height of jammer antenna above sea level in meters (386 meters)
- Pj** Power output of the jammer in watts (1,500 watts)
- ht** Height of enemy transmitting antenna above sea level (ASL) in meters (385 meters)
- JSR** Jamming to signal ratio (JSR) (8:1 (9dB))
- dj** Jammer location to target receiver location distance in kilometers (solve)
- n** Terrain and conductivity Factor (4)
 - 2 = Level terrain (over water, lakes, and ponds) good conductivity for a JSR of at least 2:1
 - 3 = Rolling hills (farmland type terrain), good conductivity for a JSR of at least 4:1
 - 4 = Moderately rough terrain (high hills), fair to good conductivity for a JSR of at least 8:1
 - 5 = Very rough terrain (mountains or desert terrain) poor conductivity for a JSR of at least 16:1
- K** Jammer tuning accuracy factor (2)
 - 2 = For jamming FM receivers operating in the VHF range
 - 3 = For jamming continuous wave (CW) or amplitude modulated receivers operating in the very high frequency (VHF) range

Figure B-1. Signal-to-Noise Ratio Formula

B-2. The use of this formula will provide for the creation of a range fan which, when plotted for different radios and signal strengths and broken down into varying ranges between transmitters and receivers, will allow for a

general range fan. This range fan will in turn provide the SIGINT teams with the means to effectively place teams and to determine which target areas can be affected by specific locations.

FUTURE TRENDS

B-3. The shortcoming of this formula is in its lack of any relationship to vegetation or signal frequency. These two factors affect the signal-to-noise ratio to such a degree that only a rough estimate as to a true range fan is determined. One possible solution to this problem is a system developed and designed by the Electronic Proving Ground (EPG). The Virtual Electromagnetic C⁴I Analysis Tool (VECAT) is designed to provide different users with powerful command, control, communications, computers, and intelligence (C⁴I) system analysis capabilities embedded in a user-friendly graphical user interface (GUI) environment. For example:

- A communications engineer or spectrum manager can use VECAT to plan specific communication links or perform area site analysis.
- An intelligence tester may use VECAT to plan evaluations of a sensor system immersed in a battlefield environment which would be impractical to duplicate in a field test situation.

B-4. VECAT employs terrain integrated rough earth model (TIREM) as its core EM propagation analytical engine. TIREM was developed by the Joint Spectrum Center (JSC) in the 1970s and is used for calculating EM-wave propagation loss between antennas above a point-by-point representation of the terrain elevations along an irregular profile of the earth.

B-5. TIREM evaluates the geometry of the defined path, determines appropriate modes of propagation, and applies suitable algorithms to calculate the path loss for the dominant mode. As a legacy model, TIREM suffers from lack of modern user amenities, such as GUI input interfaces and graphical output formats.

B-6. In VECAT, a powerful graphics interface is used to display the TIREM results. This allows the user to view either two- or three- dimensional (2D or 3D) data in a variety of combinations and styles. To facilitate its use, VECAT employs a Geographic Information System (GIS) and an Relational Database Management System (RDBMS) back-end. The GIS allows the user to place equipment in realistic positions. The equipment can be chosen from a database of known equipment and its deployment configuration can be stored in a database. The user can customize the calculations, thus accounting for a multitude of equipment characteristics and physical phenomena.

B-7. An important part of VECAT is the C⁴I standard, which is essentially the Army doctrinal dispersion of C⁴I assets in a geographic area of interest. With VECAT, the user can create and edit deployments and view communication links and their terrain profiles and area elevation data. VECAT provides a visual selection system, allowing the user to easily access the equipment in the deployment; the selection system permits the user to work with only those pieces of equipment satisfying specific criteria. The user can evaluate any subset of deployment. For instance, a user can

evaluate the area coverage of a specific EA asset against specific targets in the EM spectrum.

B-8. For decades, communicators have been concerned with RF propagation path loss through foliage. EPG has developed, implemented, and integrated into VECAT the EM Wave Attenuation in a Forest (EWAF) propagation model, which uses conventional inputs to estimate plausible foliage losses. The EWAF is an elementary, heuristically based foliage propagation path loss model that represents a forest as a dissipative dielectric slab lying in a more loosely half-spaced representation of the ground. Modeling the foliage by a dielectric slab provides an estimate of foliage excess-path-loss (EPL) expected in situations where meager information is available regarding wood density, conductivity, and other electrical parameters of the forest.

B-9. The EWAF model uses empirical foliage path-loss information as a basis and is therefore closely coupled to actual path-losses encountered in real-world situations. The EWAF model is not a rigorous attempt to solve the EM wave equations at the boundaries of the different representative dielectric slabs. EWAF is essentially a family of curve-fitting algorithms based on previously measured data for sparse and dense forests in the United States and Germany, as well as a very dense forest in India, where the mean annual rainfall is about 3 meters.

B-10. Features of the EWAF model include the effects of antennas within the forest, outside the forest, and above the forest; wave polarization; forest density; canopy, trunk, and undergrowth losses; antenna beamwidth; wet foliage; lush foliage; and other physical or forest conditions. The model provides a good estimator for EPL due to foliage anywhere in the world.

B-11. VECAT provides a powerful, flexible C⁴I analysis tool for a wide range of users. The interface is user-friendly and provides output customized to the user's needs. VECAT is expandable and well documented. It is developed to contemporary standards and uses and reuses existing software when practical. VECAT is a modern system, available now to meet a wide variety of user's needs. VECAT will provide an easy medium in which to perform engineering analyses, evaluations, and planning studies in the following functional areas:

- Fundamental EM wave propagation analyses over digital terrain.
- Receive signal level (RSL), often incorporating 3D antenna patterns.
- LOS and terrain masking effects.
- Path profile terrain evaluations.
- Signal-to-interference ratio (S/I) and bit error rate (BER) studies.
- Electromagnetic environmental effects (E3) electric field distributions.
- Spectrum usage and signal modulation.
- Co-site EMI, remote interferer, and jammer studies.
- Fade-and-noise modeling.
- EM wave propagation through foliage.